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Some Measurements of Voltage Amplification of Audio-Frequency Amplifiers.

In order to compare the effectiveness of audio-frequency amplifiers for use in radio communication, it is desirable to make measurements of the voltage amplification at frequencies over the audible range. The methods commonly used at the Bureau of Standards for measuring the voltage amplification of amplifiers are described in Bureau of Standards Letter Circular 86. A number of these amplifiers were designed for use with radio receiving sets on which reports are given in a separate series of four letter circulars (the first two of which are LC 90 and LC 93).

This paper gives the results of voltage amplification measurements made on 16 audio-frequency amplifiers which are considered as being typical of those which were on the market during the years 1921-22. Measurements were made over a frequency range from 400 to 2100 cycles per second. The particular amplifiers studied are referred to by arbitrary reference numbers rather than by a statement of the manufacturers' names and type or model numbers. It is believed that the methods followed and the examples given in this report will be of assistance to manufacturers in the development of methods of testing and describing their own products and thus improving them. It is believed that purchasers will also be directly aided in deciding what features and characteristics to look for in the selection of apparatus.

All the amplifiers included in this paper employed transformer coupling. A typical schematic circuit diagram is shown in Fig.1. The ratio E/e is measured directly by the method referred to. (e = input voltage, E = voltage produced across the telephones.) It is desirable that measurements be made with various amplitudes of the emf e as well as at various frequencies.

The values of voltage amplification at 500, 1000, 1500 and 2000 cycles per second are given in Tables I and II. Figs. 2 and 3 give curves of voltage amplification (E/e) plotted against frequency for 4 amplifiers. These curves are representative of those obtained for all the amplifiers covered by this test. Fig.2 shows the results on 2 single-stage amplifiers and Fig.3 on 2 two-stage amplifiers. It may be seen from these curves and from Tables I and II that the amplification is not uniform over the complete audio-frequency range, the amplification usually being greatest at one frequency which represents the

natural period of some circuit in the apparatus. This lack of uniformity is an indication of the amount of distortion in the received signal which will be introduced by the amplifier, the ideal amplifier for amplification of musical tones having a curve parallel to the frequency axis. It is not usually possible to secure all desirable characteristics in a single piece of apparatus. For example, in order to secure the best possible quality it may be necessary to use a set which sacrifices some amplification. Commercial questions such as cost are also involved in the selection of apparatus for purchase.

It must be remembered that some distortion may be due to the electron tubes used in the amplifier and that the shape of the curves will not necessarily be the same for different types of electron tubes and for different values of the input voltages.

The values of e and E depend on the characteristics of the input and output circuit. It is probable that better ratio would be one that was independent of these circuits. Such a ratio may be calculated if the values of the various constants of the test circuits are known. Fig. 4 shows the external circuits of an amplifier. If Z_1 and Z_1' are known, a voltage e' which it would be necessary to insert in the input circuit to produce e may be calculated by

$$e' = \frac{e\ (Z_1 + Z_1')}{Z_1'}$$

additional being made vectorially. Likewise the voltage E' necessary in the output circuit to produce E may be calculated by

$$E' = \frac{E\ (Z_2 + Z_2')}{Z_2}$$

From the ratio of $\frac{E'}{e'}$ could be calculated the value of $\frac{E}{e}$ for any known external circuits when the constants of the external circuits used during test are known. The ratio $\frac{E'}{e'}$ was not calculated in this series of tests.

Table 1.
One-stage Amplifiers.

Amplifier No.	Voltage Amplification			
	500~	1000~	1500~	2000~
1922 AB	10	14.5	16.5	17.5
1922 AC	20	29.5	27.5	24.0
1922 AD	12.5	17.0	20	21.5
1922 AE	12.0	16.0	20	21.5
1922 AF	4.0	7.0	9.7	11.0

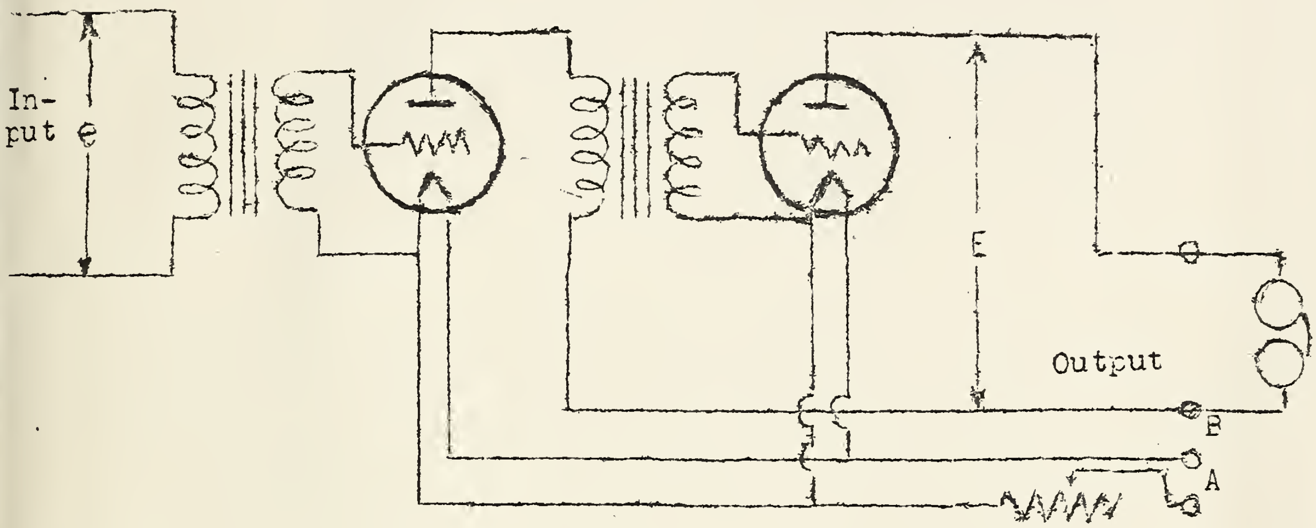


Fig. 1

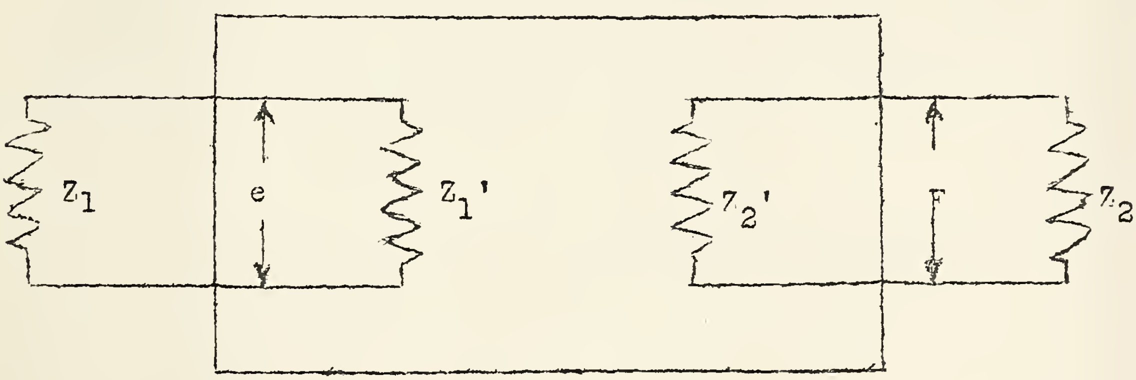


Fig. 4

Fig. 2

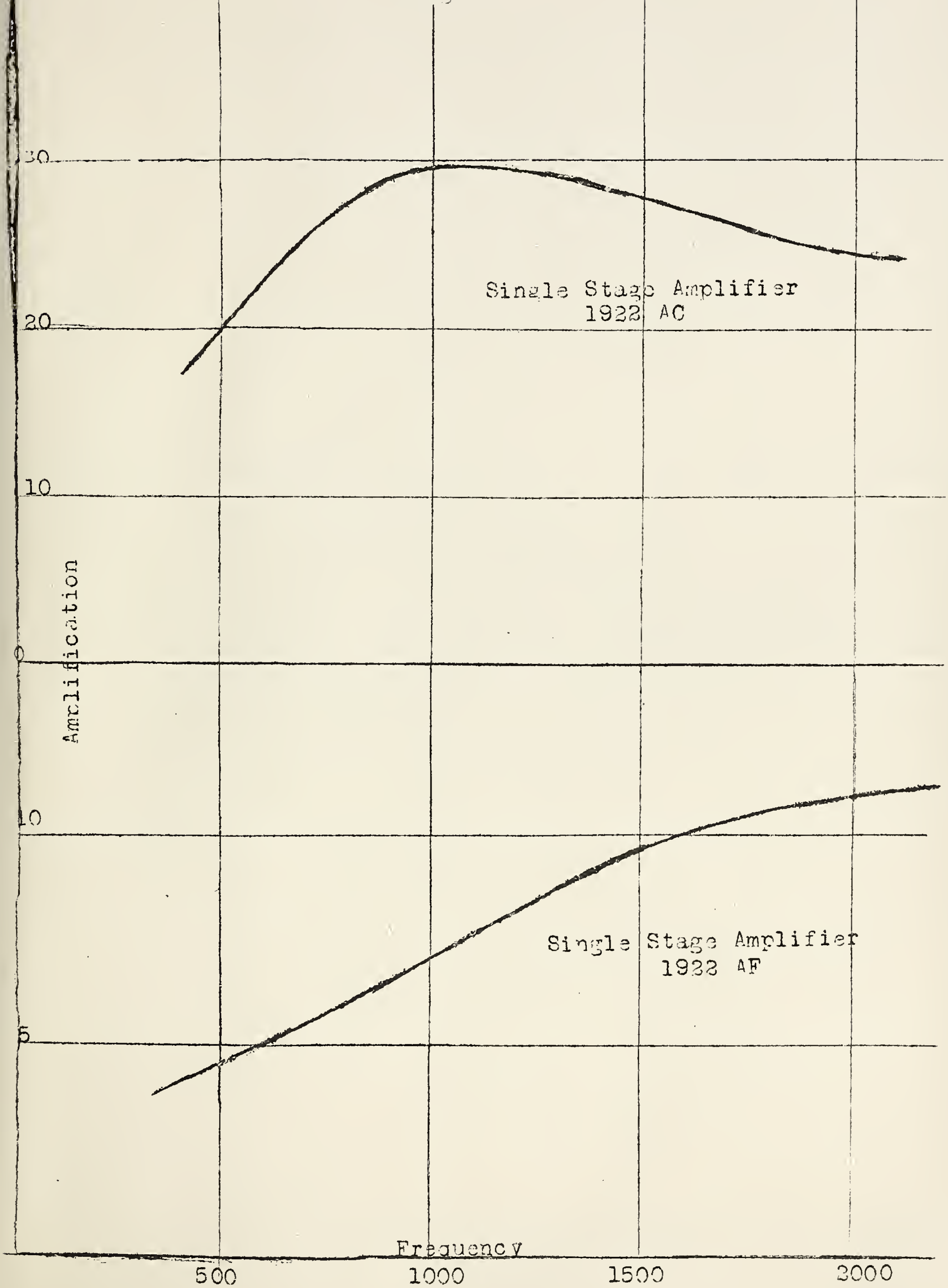
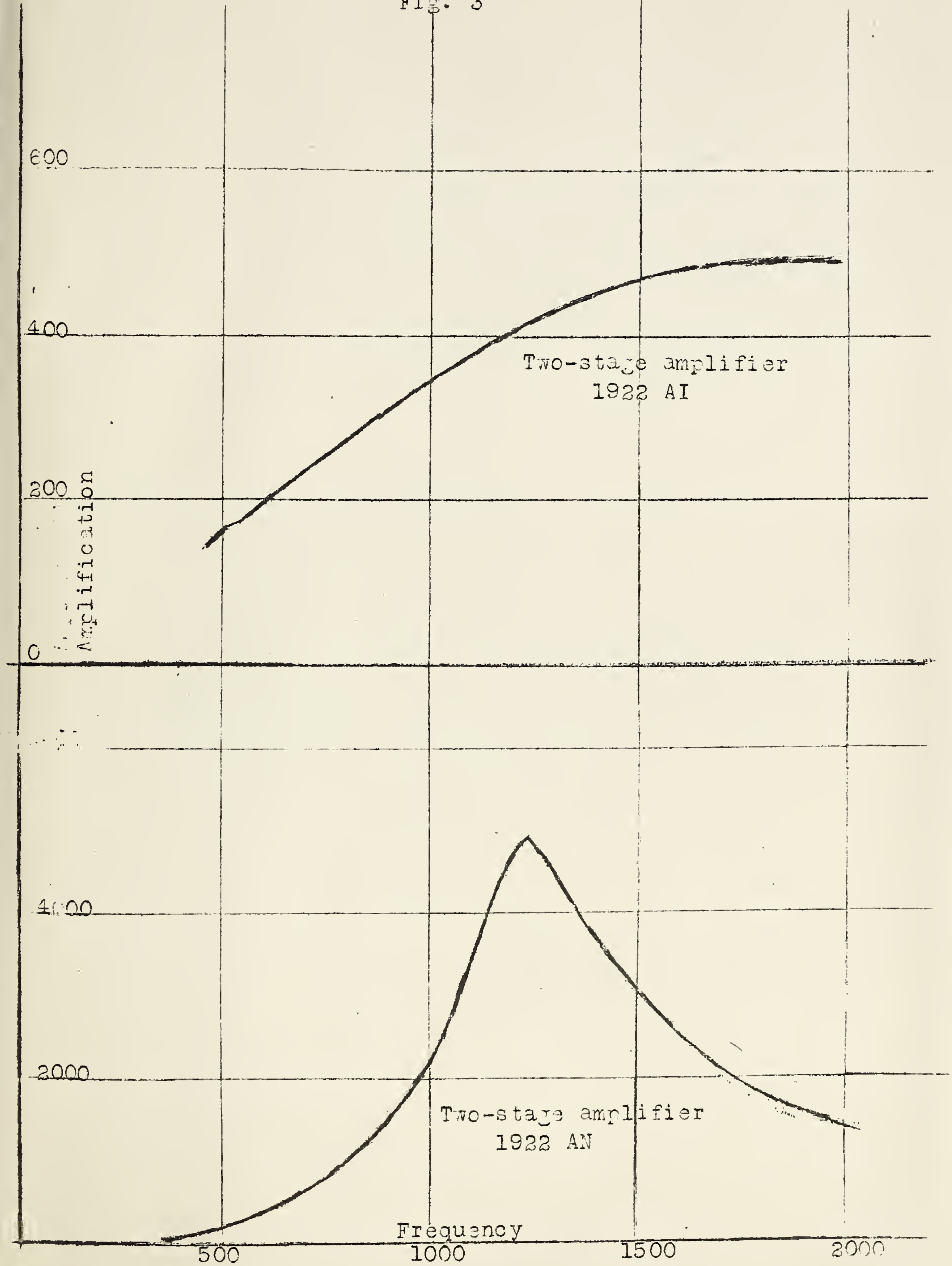

Single Stage Amplifier
1922 AC
Single Stage Amplifier
1922 AF
Amplification
Frequency
30
20
10
0
10
5
500
1000
1500
3000

Fig. 3


600
400
200
0
Amplification
Two-stage amplifier
1922 AI
4000
2000
Two-stage amplifier
1922 AN
Frequency
500
1000
1500
2000